Subject :- PRCD I

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ID :: 7821

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Section :: A

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Q1

Given data:-

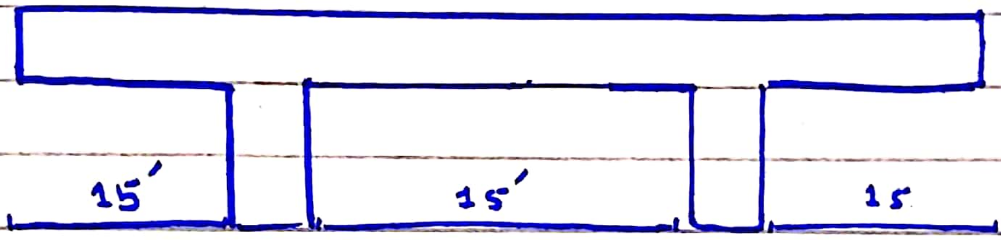
Factored live load = 160 lb/ft²

Service floor finish load = 20 lb/ft²

$f_c' = 4000$ Psi , $f_y = 40$ ksi

3 sequal span concrete slab

Clear span b/w support = 15 ft



Step # 1 (Minimum thickness)

Using formula

$$t_{min} = l/28 = \frac{15}{28} = 6.4 \approx 6.5''$$

As $f_y = 40$ ksi

We multiply a factor with thic thickness

$$\text{factor} = \left(0.4 \times \frac{F_y}{100}\right)$$

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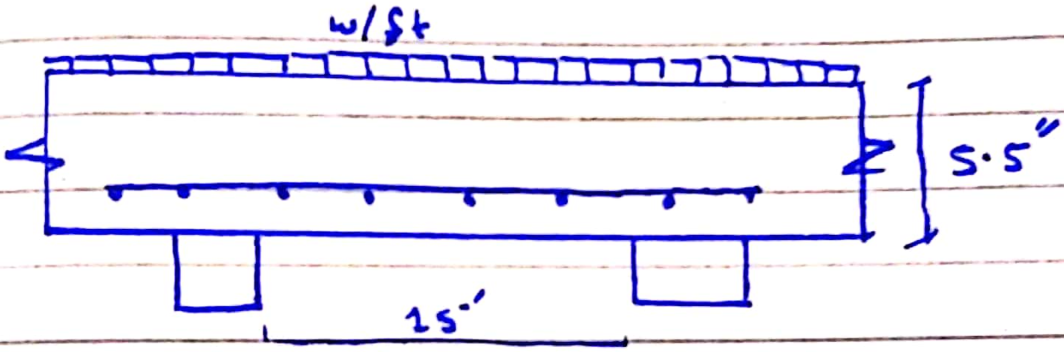
$$\text{factor} = \left(0.4 + \frac{40}{100}\right) = 0.8$$

Hence the minimum thickness will be 6.5×0.8

$$t_{min} = 5.2 = 5.5''$$

Step # 2 (Effective depth)



By formula we have

$$d = t - \text{clear cover} - \tfrac{1}{2}(\text{dia of m.b})$$

$$= 5.5 - 0.75 - 1/2\,(5/8)$$

$$\boxed{d = 4.5''}$$

Step # 03 Self weight of slab

$$\frac{t}{12} + \gamma_{concrete}$$

$$\frac{5.5}{12} + 150 = 68.75\ lb/ft^2$$

Step # 04 (Total factored load.

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Factored live load = 160 lb/ft²

the factored dead load will be

$D.L = 1.2(20 + 68.75) = 106.5\ lb/ft^2$

$T.F.L = D.L + L.L$

$= 106.5 + 160$

$= 266.5\ lb/ft^2 = 0.2665\ k/ft^2$

Step # 05 (Ultimate moment)

$$M_u = \frac{w_u \times L^2}{8} = \frac{0.2665 \times (15)^2 \times 12}{8}$$

$= 89.94$ kip-Inch

Step # 06 Area of Steel for M.B

By trial & Repeat method.

Trial # 01

Let depth of Compression block

$a = 0.2 \times t \Rightarrow 0.2 \times 5.5$

$a = 1.1''$

$$A_{st} = \frac{M_u}{\phi \times f_y \times (d - a/2)} = \frac{89.94}{0.90 \times 40 \times (4.5 - 1.1/2)}$$

$A_{st} = 0.63\ in^2$

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Trial # 02

$$a = \frac{Ast \times fy}{0.85 \times f'c \times b} = \frac{0.63 \times 40}{0.85 \times 4 \times 12}$$

$a = 0.62 in^2$

$$Ast = \frac{Mu}{\phi \times fy \times (d - a/2)} = \frac{89.94}{0.90 \times 40 \times \left(4.5 - \frac{0.62}{2}\right)}$$

$Ast = 0.59 in^2$

Trial # 03

$$a = \frac{0.59 \times 40}{0.85 \times 4 \times 12} = 0.57''$$

$$Ast = \frac{89.94}{0.90 \times 40 \times \left(4.5 - \frac{0.57}{2}\right)} = 0.59 in^2$$

So we will use $Ast = 0.59 in^2$

Step # 07 Area of Steel for distribution reinforcement.

$A_{min} = 0.002 \times b \times t$ (for grade 40 steel)

$A_{min} = 0.002 \times 12 \times 5.5 \Rightarrow 0.132 in^2$

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Step # 08 Spacing for M.B

Spacing $\frac{A_b}{A_{st}} \times 12 =$

We use #6 bar dia $= \left(\frac{6}{8}\right)''$

Area $= \frac{\pi}{4} \times \left(\frac{6}{8}\right)^2 = 0.442\ in^2$

Step # 09 Spacing for distribution bars.

Spacing $\frac{A_b}{A_{st}}$ we use #5 bar

dia $= \left(\frac{5}{8}\right)''$, Area $= \frac{\pi}{4}\left(\frac{5}{8}\right)^2 = 0.31 in^2$

Spacing $= \frac{0.31 \times 12}{0.132} = 28.1 \simeq 28.1$

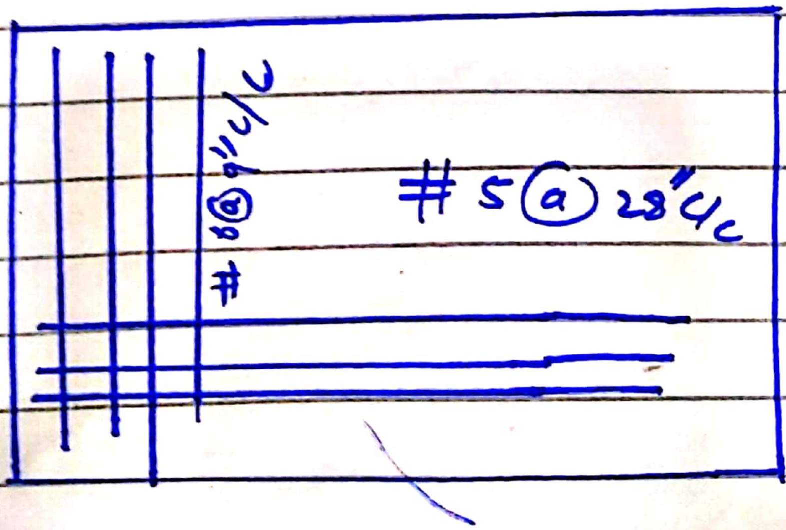
$\simeq 28''$ c/c

Step # 10 Final Sketch

$F_c' = 4ksi$, $f_y = 40ksi$

Mainsteel #6 at 9" c/c

Distribution steel #5 at 28" c/c



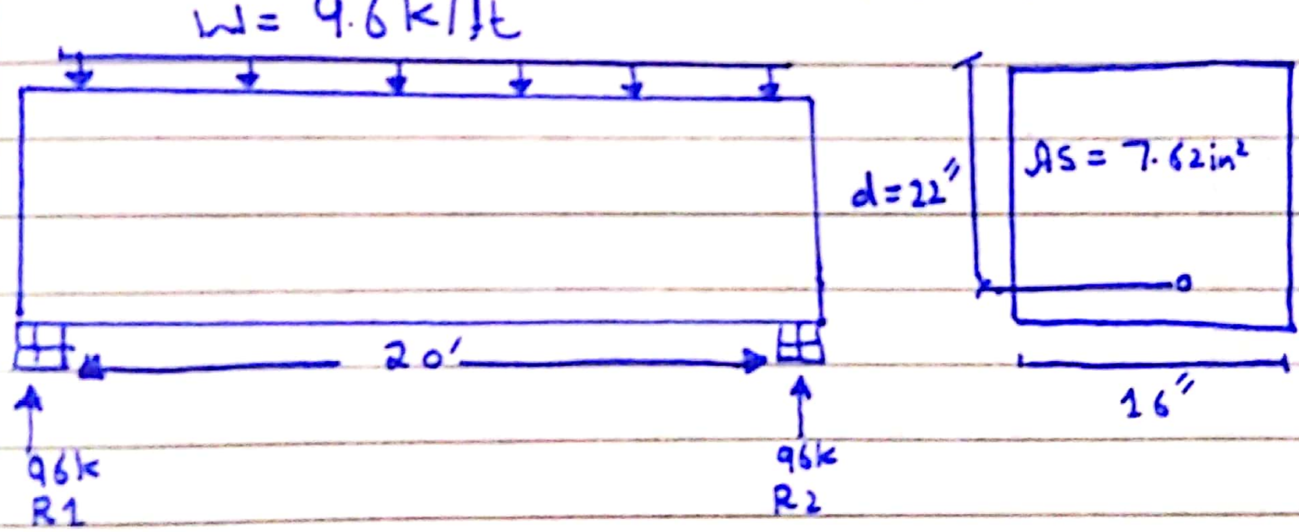
Q2 A Simply Supported rectangular beam 16" wide having effective depth of 22" caries . . . . .
. . . . using #3 Stirrup as vertical U-stirrup.

Sol:-

At First find the unit load of beam So $b \times \gamma_c$

$$\frac{16}{12} \times 150 = 200\ lb/ft = 0.2k/ft$$

total factored load = 9.4 + 0.2
= 9.6k/ft



Step 01# Find value of "R1" & "R2".

$$\text{total load} = 9.6 \times \frac{20}{2} = 96K$$

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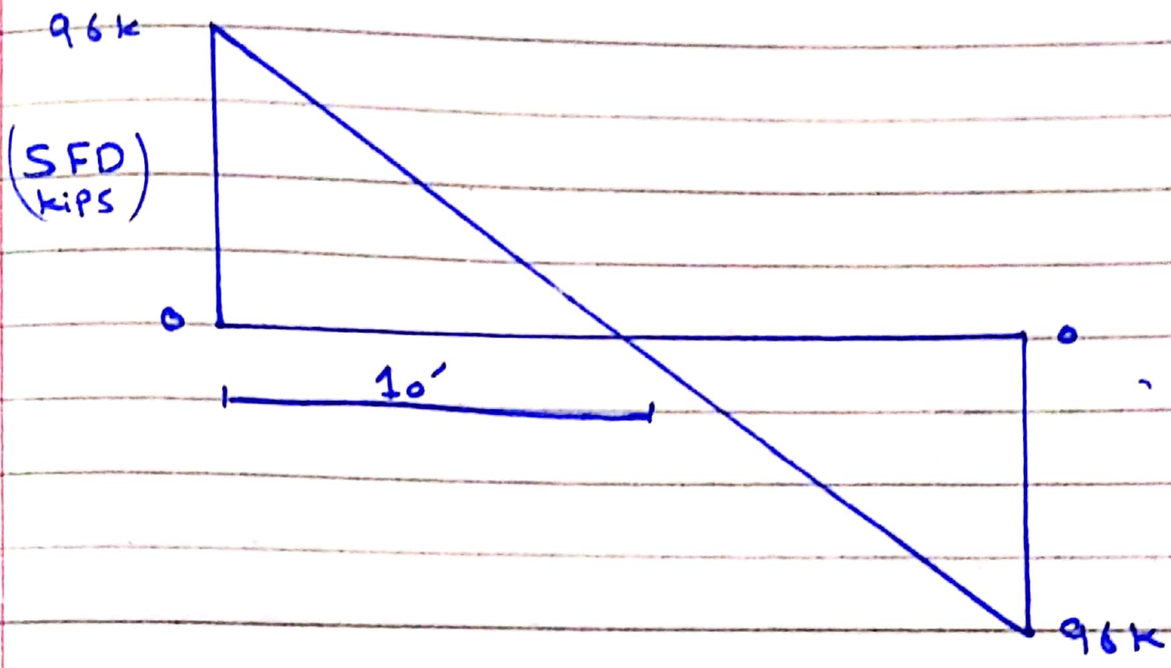
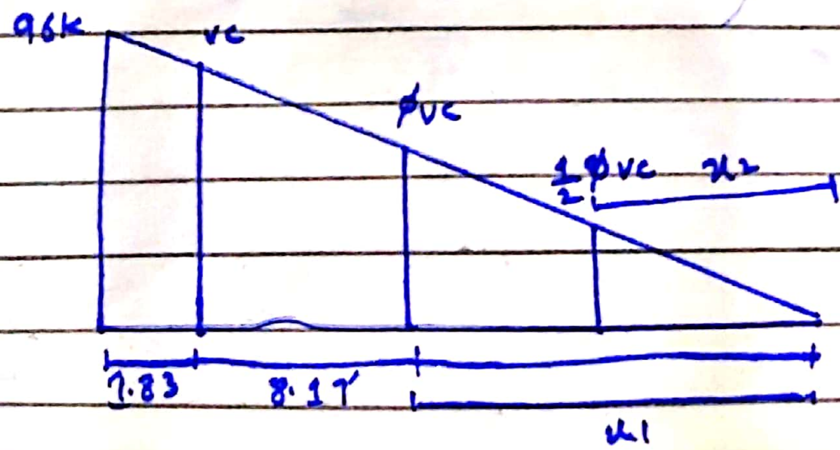
Step # 02 Draw its Shear Force diagram.



Step # 03 Finding value of Critical Stress "Vu" & its location.

As we know that critical location is located distance "d" from face of support $d = 22'' = 1.83'$ value of critical Shear at distance "d" by Similarity triangles.



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From Similar Δ's $\frac{96}{10} = \frac{V_u}{8.17}$

$V_u = 78.43K$

Step 04:- Finding value of "ϕV_c" & "$\frac{1}{2}\phi V_c$" & its distance from zero shear to right side.

$\phi V_c = \phi \times 2 \times \sqrt{f'_c} \times b_w \times d = \frac{0.75 \times 2 \times \sqrt{4000} \times 16 \times 22}{1000}$

$\phi V_c = 33.40K$

location of ϕV_c by Similarity of Δs'

$\frac{96}{10} = \frac{33.40}{x_1}$

$x_1 = 3.48'$

Now

$\frac{1}{2}\phi V_c = \frac{33.40}{2} = 16.70K$

Location of $\frac{1}{2}\phi V_c \Rightarrow \frac{96}{10} = \frac{16.70}{x_2}$

$x_2 = 1.74'$

Step # 05 Find value of ϕV_s ($V_u = \phi V_s + \phi V_c$)

So we have

$\phi V_s = V_u - \phi V_c$

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$\phi V_s = 78.43 - 33.40$

$\phi V_s = 45.03k$

Step # 06 Check Section Adequacy.

$$\phi \times 8 \times \sqrt{f'_c} \times b_w \times d = \frac{0.75 \times 8 \times \sqrt{4000} \times 16 \times 22}{1000}$$

$$= 133.57k$$

133.57k > ϕV_s (mean Section is adequate)

Step # 07 Check mini Spacing for Stirrups.

$$\phi \times 4 \times \sqrt{f'_c} \times b_w \times d \Rightarrow \frac{0.75 \times 4 \times \sqrt{4000} \times 16 \times 22}{1000}$$

$= 66.79k$ > $\phi V_s = 44.03k$

thus max spacing will be selected from the following 4 Conditions.

① $S_{max} = 24''$

② $\frac{d}{2} = \frac{22}{2} = 11''$

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(3) $S_{max} = \dfrac{A_v \times f_y}{0.75 \times \sqrt{f'_c} \times b_w}$

$\therefore A_v = \frac{\pi}{4}\left(\frac{3}{8}\right)^2 \quad \because A_v = 0.11 \times 2 = 0.22$

$S_{max} = \dfrac{0.22 \times 60000}{0.75 \times \sqrt{4000} \times 16}$

(4) $S_{max} = \dfrac{A_v \times f_y}{50 \times b_w}$

$S_{max} = \dfrac{0.22 \times 60000}{50 \times 16} = 16.50$

From the above 4 Conditions, least value of Spacing for #3 U shaped will be Selected So $S_{max} = 11''$ c/c

Step#08 Spacing of Stirrup from at Critical section.

$S = \dfrac{\phi \times A_v \times f_y \times d}{V_u - \phi V_c} = \dfrac{0.75 \times 0.22 \times 60 \times 22}{78.43 - 33.40}$

$S = 4.84 \simeq 5''$ c/c

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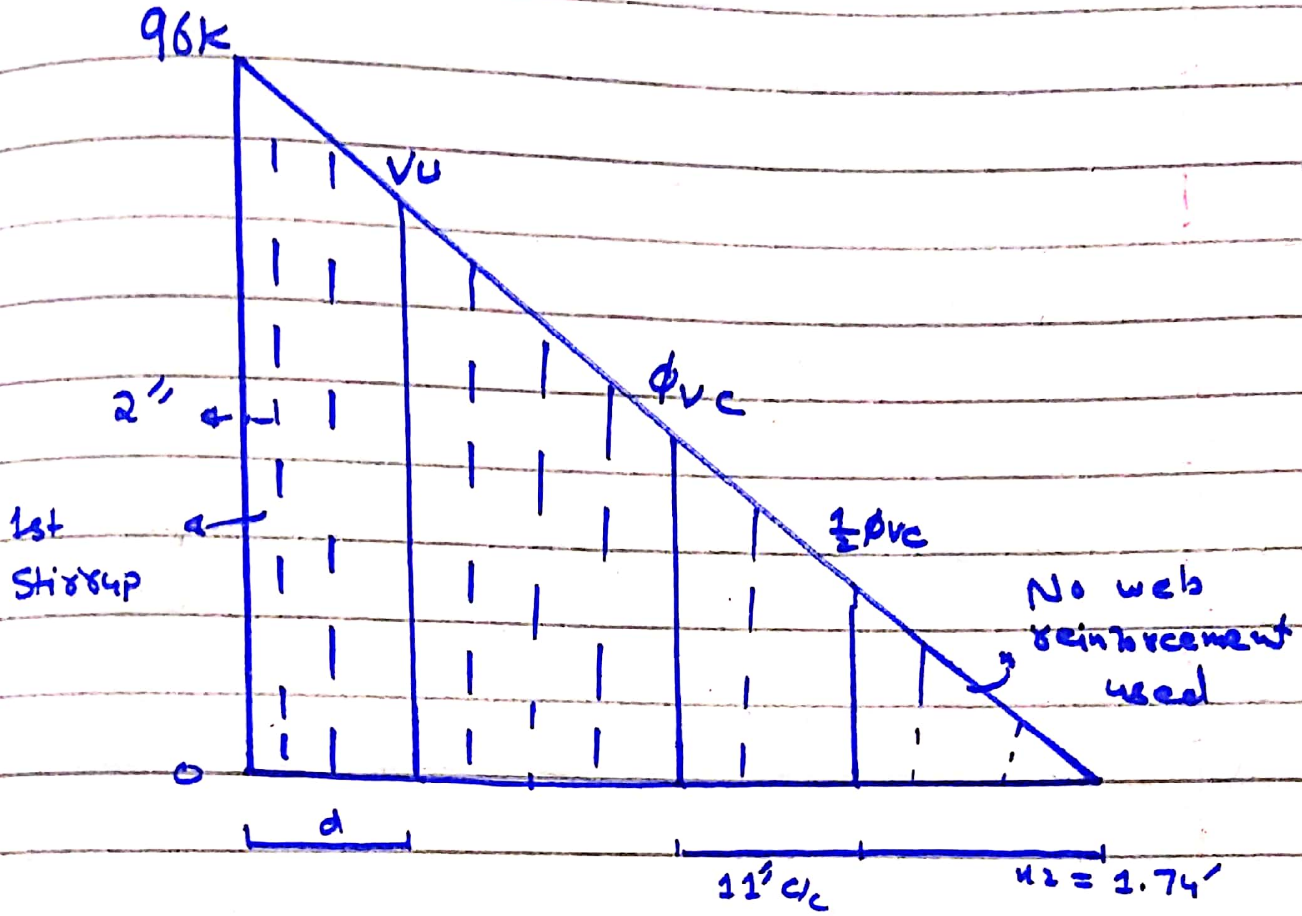
Step # 09 "Final Sketch"



We know that first Stirrup from face of Support = $\frac{5}{2} = 2.5 \simeq 2''$

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Q3 Calculate the axial ultimate . . . . Design necessary Spirals.

Sol:-

Step #01 Find gross Area of Concrete.

$A_g = b \times b$ (Since it is Square tied Column)

$A_g = 12 \times 12 = 144 in^2$ (Actual)

Step #02 Find area of Steel

Since $A_s = 5\%$ of A_g

$= 0.05 \times 144$

$A_s = 7.2 in^2$

Step #03 "U/C Capacity"

$P_u = \phi \times 0.80 \times [0.85 \times f'_c \times (A_g - A_s) + A_s \times f_y)$

$= 0.65 \times 0.80 [0.85 \times 4 \times (144 - 7.2) + 7.2 \times 60]$

$P_u = 466.50 k$

Step #04 Sketch & design of ties (C/C to distance)

From the below value we choose the last value of all thus.

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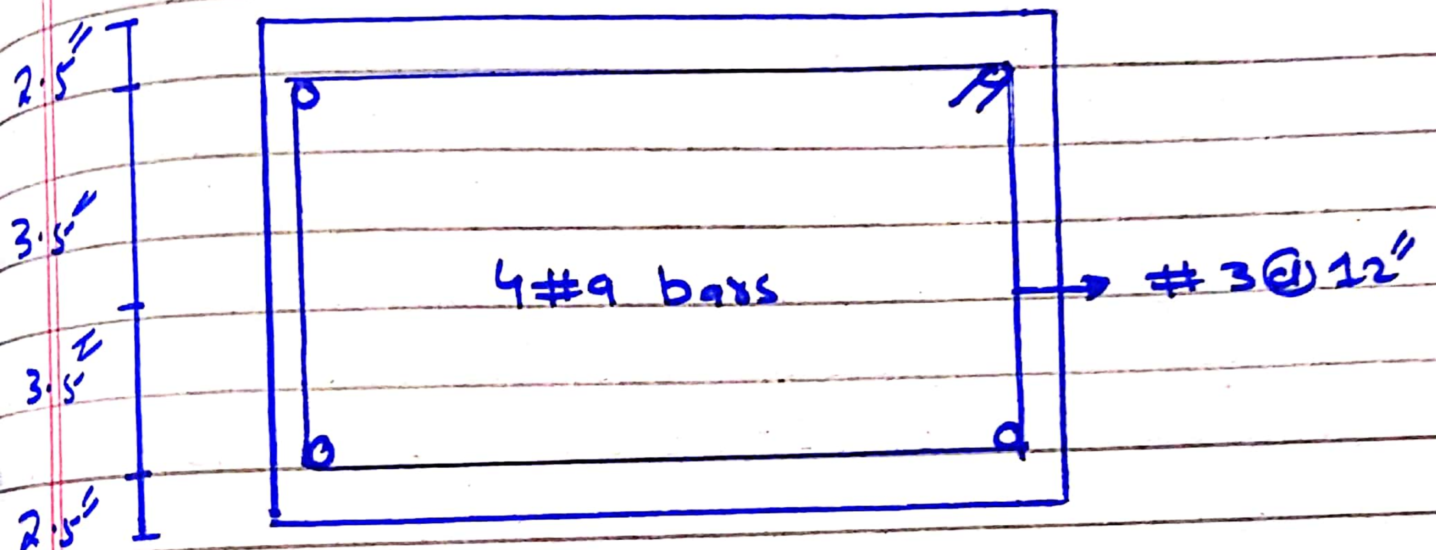
(1) 16×dia of long bar = $16 \times 9/8$ = 18"

(2) 48×dia of tie bar = $48 \times 3/8$ = 18"

(3) least common dimension = 12" so c/c distance b/w ties = 12"



"So According to me its a square column so there will be no spiral stirrup used, the stirrup used in of rectangular shape due to the specification of the structure so we use tie stirrup instead.

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Qu Design a Square single footing to . . . . Draw a sketch of your final design.

Step 01:

Let $h = 24''$

Step #02

Total weight = wt of soil + wt of RC

$= 3 \times 120 + 2 \times 150$

$= 660 \text{ Psf} = 0.660 \text{ Ksf}$

Step #03 Effective bearing Capacity.

$q_e = q_a - w$

$q_e = 2.50 - 0.660$

$q_e = 1.84 \text{ Ksf}$

Step # 04 Required Area of foundation.

$$A = \frac{\text{Service load}}{q_e}$$

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$$= \frac{100 + 120}{1.84} = 119.57\ ft^2$$

Step # 05 foundation is Square.

$Area = b \times b = 119.57 \Rightarrow B \cong 11'$

Step # 06 upward bearing Capacity of Soil.

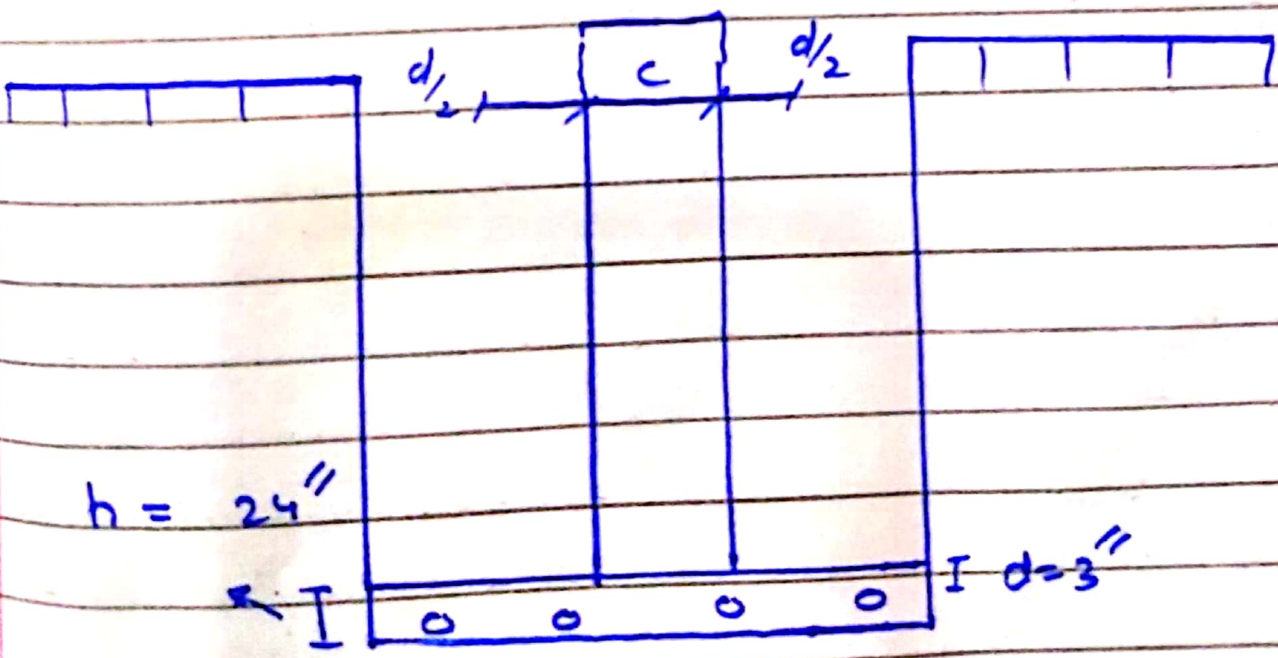
$$q_{up} = \frac{\text{factored load}}{(B)^2}$$

$$= \frac{1.2 \times 100 + 1.6 \times 120}{(11)^2}$$

$q_{up} = 2.58\ k/ft^2$

Step # 07 Punching Shear

$b_o = 4 \times (c + d)$



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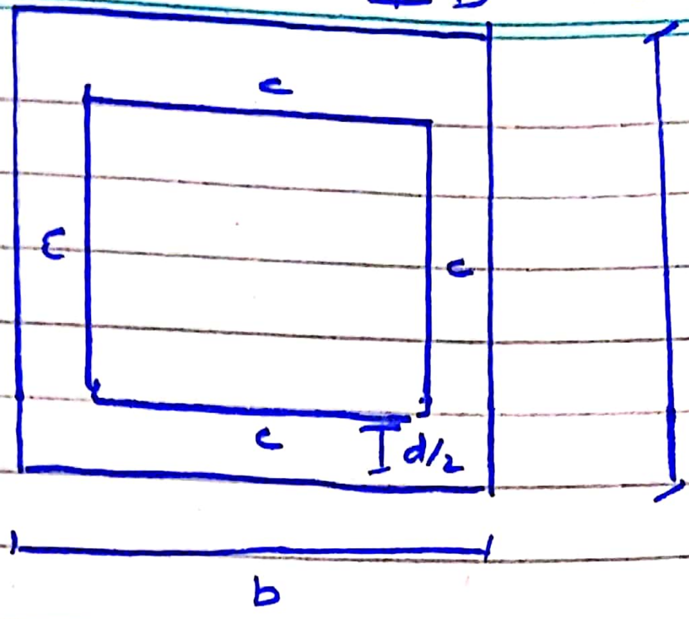

d = h - c.c - dia of bar - 1/2 d_b

= 24 - 3 - 1 - 1/2 (1) = 19.5"

Let # 8 bar
dia = 8/8 = 1"

$b_o = 4 \times (16 + 19.5)$

$b_o = 142"$

Step # 08

$V_{u2} = q_{up} \times \left[B^2 - (c+d)^2 \right]$

$V_{u2} = 2.58 \times \left[11^2 - \frac{(16 + 19.5)^2}{12} \right]$

$V_{u2} = 289.60k$

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Step # 09

$$\phi V_{c/p} = \phi \times 4 \times \sqrt{f'_c} \times b \times d$$

$$= \frac{0.75 \times 4 \times \sqrt{4000} \times 142 \times 19.5}{1000}$$

$$\phi V_{c/p} = 525.38$$

Step # 10 Beam Shear one way Shear check.

$$V_{u1} = q_{up} \times B \times \left[B/2 - c/2 - d \right]$$

$$V_{u1} = 2.58 \times 11 \times \left[11/2 - \frac{16/12}{2} - 19.5 \right]$$

$$\boxed{V_{u1} = 90.95k}$$

Step # 11 Self Shear Capacity

$$\phi V_c = \phi \times 2 \times \sqrt{f'_c} \times b \times d$$

$$= \frac{0.75 \times 2 \times \sqrt{4000} \times [11 \times (22 - 16)]}{1000}$$

$$\phi V_c = 110.04 > V_{u1} \Rightarrow okay$$

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Step # 12 Ultimate moment

$$M_u = \frac{q_{up} \times B}{8} \times (B-C)^2 = \frac{2.58 \times 11}{8} \times \left(11 - \frac{16}{12}\right)^2$$

$$M_u = 331.49k' \simeq 3977.93k''$$

Step # 13 Area of Steel for M.B by trial & repeat method.

Trial No 1#

Let $a = 0.2 \times h = 0.2 \times 24 = 4.8''$

$$A_s = \frac{M_u}{\phi \times f_y \times (d - a/2)} = \frac{3977.93}{0.90 \times 60 \times \left(11 - \frac{4.8}{2}\right)}$$

$$A_{s1} = 8.56 in^2$$

Trial No 2#

$$a = \frac{A_s \times f_y}{0.85 \times f'_c \times b} = \frac{8.56 \times 60}{0.85 \times 3 \, (11 \times 12)} = 1.53''$$

$$A_{sf} = \frac{3977.93}{0.90 \times 60 \times \left(11 - \frac{1.53}{2}\right)} = \boxed{7.19 \, in^2}$$

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trial # 03

$$a = \frac{7.197 \times 60}{0.85 \times 3 \times 11 \times 12} = 1.28''$$

$$A_{st} = \frac{3977.93}{0.90 \times 60 \left(11 - \frac{1.28}{2}\right)} = 7.1 in^2$$

So that area = $7.1 m^2$.

Step # 14 Check the min reinforcement by the following 3 method.

(a) $A_{smin} = 0.0018 \times B \times h = 0.0018 \times (12 \times 11) \times 24$

$A_{smin} = 5.70 in^2$

(b) $A_{smin} = \frac{200}{f_y} \times B \times h = \frac{200}{60000} \times (11 \times 12) \times 19.5$

$8.58 in^2$

(c) $A_{smin} = \frac{3 \times \sqrt{f'_c}}{f_y} \times B \times d$

$$= \frac{3 \times \sqrt{3000} \times (11 \times 12) \times 19.5}{60000}$$

$$= 7.05 in^2$$

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From above value greater value will be Selected thus $As_{min} = 8.58 in^2$

Step # 18 using # 8 bars.

$Ab = 0.785 in^2$

$\text{No of bars} = \frac{As}{Ab} = \frac{8.58}{0.785} = 10.92$

$10.92 \simeq 11$ bars in each direction

11 # 8 bar

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